

LOW TEMPERATURE EVALUATION OF THE UCC3581VOLTAGE-MODE PWM CONTROLLER

Test Report

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Background

The Texas Instrument/Unitrode UCC3581 is a BiCMOS voltage-mode pulse width modulation (PWM) controller chip for low power dc-dc converter applications [1]. The primary use of this device is for single switch forward and flyback converters at frequencies up to 100 kHz. Some of the features of the device include a built-in startup preregulator that provides regulation of the device supply voltage (VDD) via an external N-channel MOSFET in converter designs utilizing external bootstrap circuitry. This device was selected for evaluation for potential use in the development of a low temperature dc-dc converter module. The performance of the BiCMOS-structure devices at low temperature is questionable. Typically, CMOS devices perform relatively well down to approximately liquid nitrogen temperature (-196 °C). Bipolar devices, on the other hand, are known to suffer performance degradation at low temperature. BiCMOS devices are a hybrid of these two families and as such may or may not perform well at low temperatures.

Test Setup

The Texas Instrument UCC3581 device was characterized from room temperature to -190 °C in a liquid nitrogen cooled chamber. Figure 1 shows the experimental circuit layout used in this investigation. The device was characterized at test temperatures of 25, -25, -50, -100, -125, -150, -175 and -190 °C. At each test temperature, the device was allowed to soak for 15 minutes before measurements were made.

This work examined only limited functions of the device due to its complexity. These included the preregulator driver threshold voltage (GT), the device reference voltage, switching frequency, and duty cycle. The threshold voltage was determined when the supply voltage was increased sufficiently to cause a shutdown of the preregulator. At this stage, an external bootstrap circuit will govern the input voltage supplying the device.

The switching frequency was programmed via two resistors and a capacitor to approximately 45 kHz. The duty cycle of the device was obtained as a function of a programmable control voltage (VC) that had a range from 1.0V to 2.5V.

Results and Discussion

The preregulator threshold voltage (GT), reference voltage, and switching frequency are shown at various temperatures in Table I. It can be clearly seen that all of these properties did not exhibit appreciable change with temperature in the test range of 25 °C to -190 °C.

Waveforms of the device reference voltage, oscillator, and output switching voltage, which were recorded at a control voltage (VC) of 1.5V, are shown in Figure 2a and 2b at test temperature of 25 °C and -190 °C, respectively. These parameters were also recorded at a control voltage (VC) value of 2.5V and are depicted in Figure 3.

While the reference voltage and the oscillator waveforms did not undergo much change throughout the test temperature range, regardless of the control voltage level, as shown in Figure 2 and 3, the device output duty cycle showed some dependency on the test temperature. For example, at control voltage of 1.5V, the duty cycle of the device increased by about 15% from its room temperature value when

temperature reached -190 °C. This trend, however, is not observed when a control voltage of 2.5V was applied, as shown in Figure 3.

This dependency of the duty cycle on temperature is also illustrated in Figure 4 over the entire control voltage range. It can be seen that the increase in duty cycle with temperature occurs only at -175 °C and -190 °C. This increase, however, amounted to no more than 5% of the room temperature value. The test temperature seemed also to influence the effect of the control voltage on the duty cycle. The range of the control voltage, which governs the duty cycle, seems to exhibit a steady but slight decrease with a decrease in temperature. This effect is more evident at the extreme low temperature. For example, while the control voltage affecting the output duty cycle had a value between 1.2V → 2.5V at 25 °C, this effective range decreased to 1.4V → 2.2V at -190 °C. In addition, the control voltage had to be slightly greater than 1.5V in the temperature range of -125 °C to -175 °C for the device to develop an output voltage with noticeable duty cycle.

Conclusion

The UCC3581 voltage-mode PWM controller, which is a commercial-grade device rated for 0 to 70 °C operation, has been evaluated for potential use in low temperature applications. The device was characterized in terms of its preregulator threshold voltage, switching frequency, and duty cycle control in the temperature range 25C to -190 °C. While the threshold voltage and frequency did not exhibit major changes with temperature, the device output duty cycle seemed to slightly increase only at the extreme low temperatures. The results of this preliminary work indicate that the device may be capable of operation in low temperature applications. Further testing is needed, however, to establish operational performance and reliability of these devices under long term temperature exposure and thermal cycling.

References

1. UCC3581 Micropower Voltage-Mode PWM Data Sheet, Texas Instruments, Inc.

Acknowledgments

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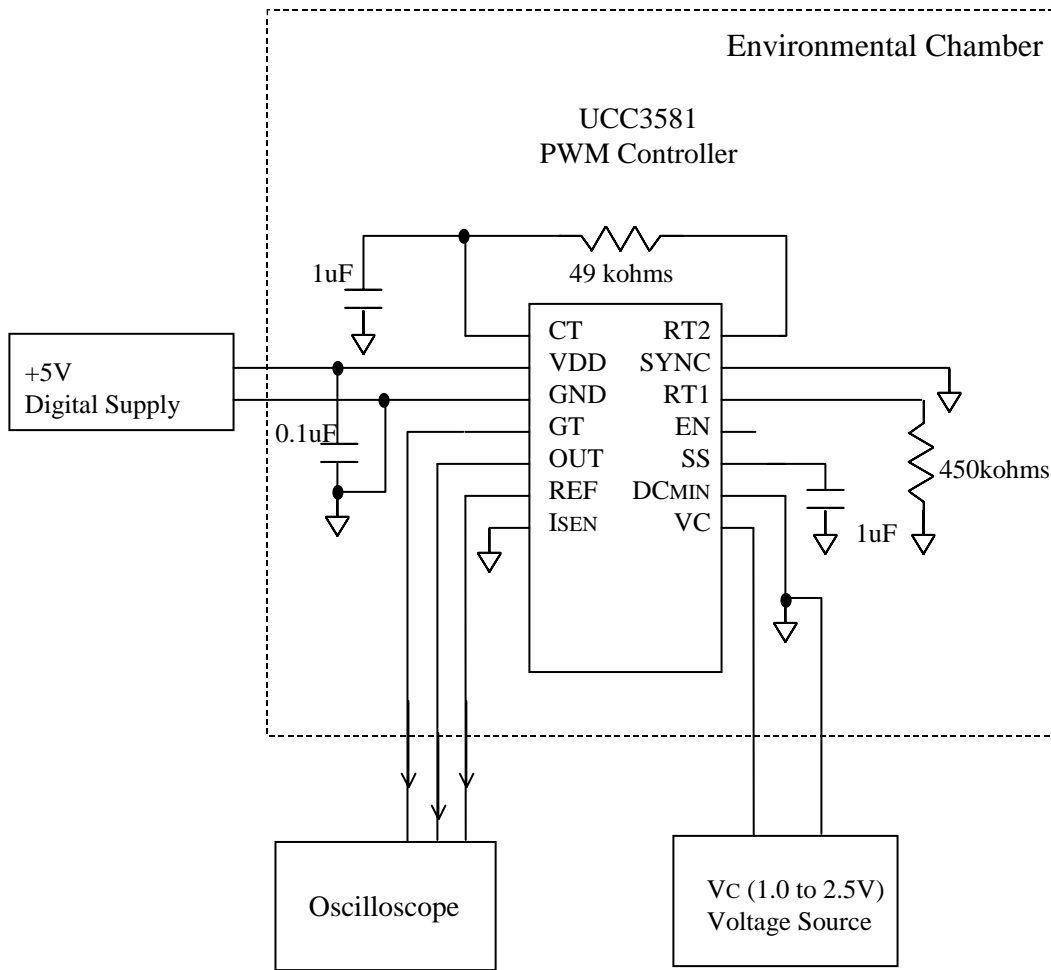


Figure 1. Test setup for UCC3581.

Table I. Preregulator threshold voltage, reference voltage, and switching frequency versus temperature.

Temperature (°C)	Threshold Voltage (V)	Reference Voltage (V)	Frequency (kHz)
25	7.7	3.95	44.2
-25	7.6	3.94	45.2
-50	7.6	3.94	45.3
-100	7.5	4.1	45.3
-125	7.4	4.2	45.1
-150	7.6	4.3	44.7
-175	7.6	4.1	44.6
-190	7.6	4	43.8
25	7.7	3.98	44.5

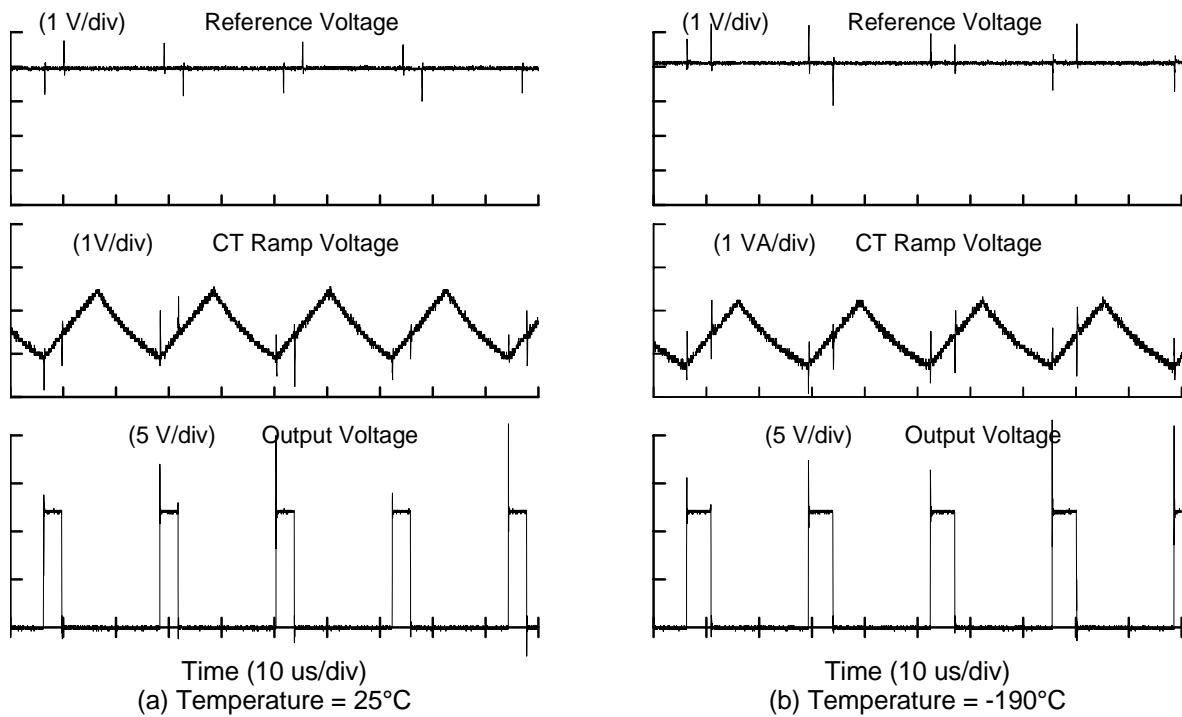


Figure 2. Reference voltage, oscillator (CT ramp signal), and output voltage waveforms at 25 °C and -190 °C for a control voltage of 1.5V.

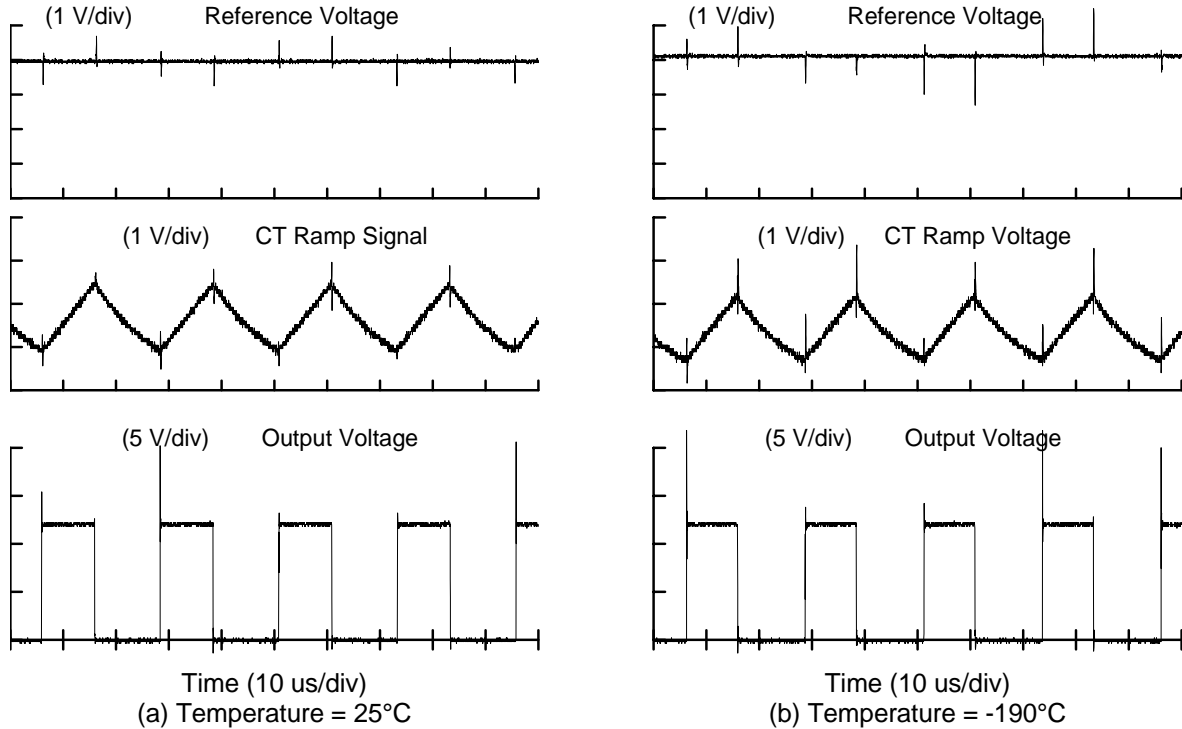


Figure 3. Reference voltage, oscillator (CT ramp signal), and output voltage waveforms at 25 °C and -190 °C for a control voltage 2.5V.

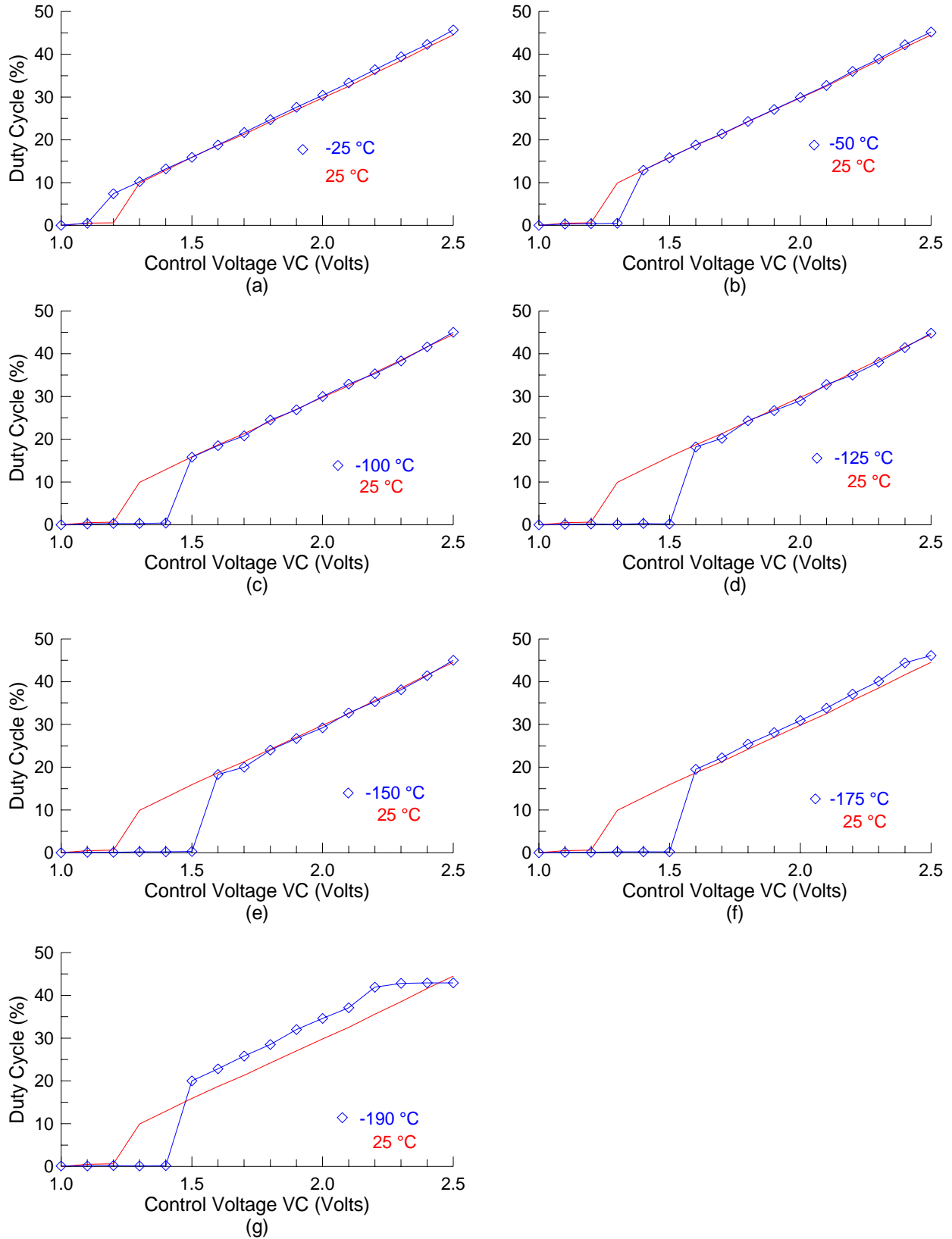


Figure 4. Duty cycle as a function of control voltage at various temperatures.